Co-Optimization of Fuels and Engines

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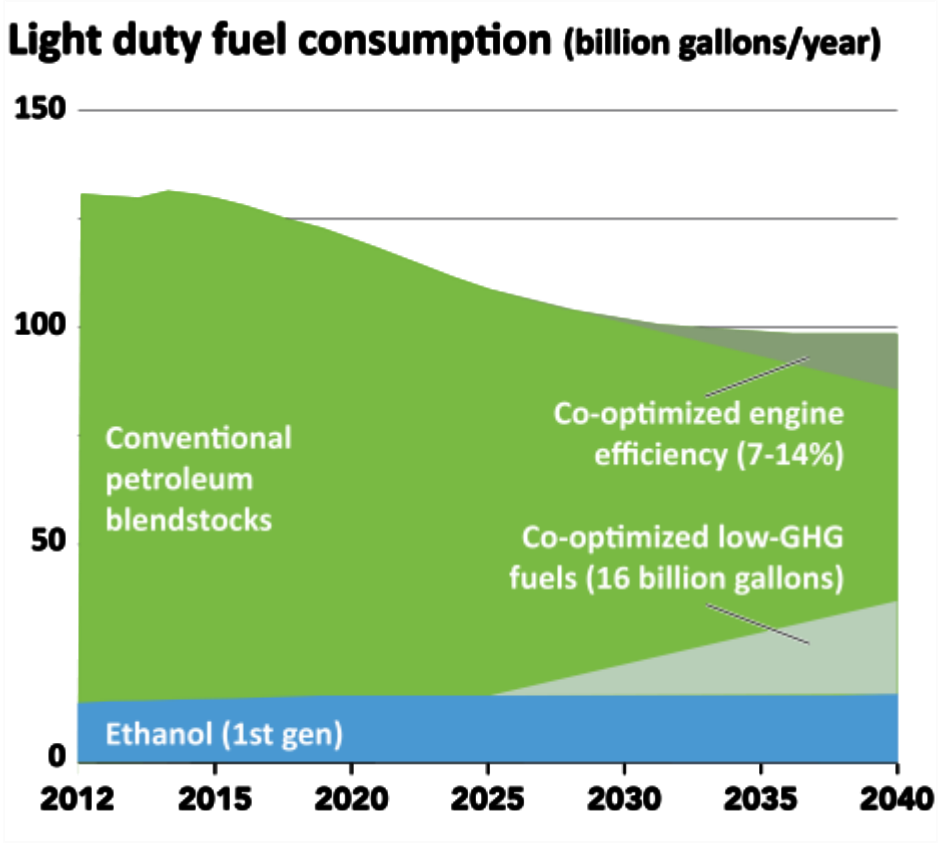
Goal: better fuels and better vehicles **sooner**

Fuel and Engine Co-Optimization

- What fuel properties maximize engine performance?
- How do engine parameters affect efficiency?
- What fuel and engine combinations are sustainable, affordable, and scalable?

30% per vehicle petroleum reduction via efficiency and displacement



source: EIA 2014 reference case

National goal:

80%

reduction in transportation GHG by

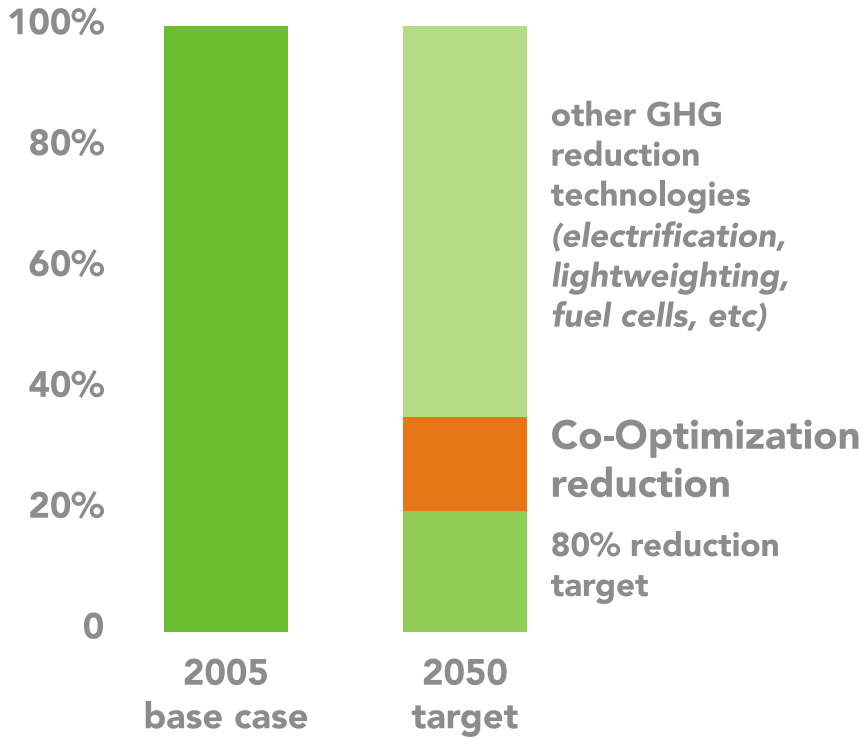
2050

Co-Optimization:

9-14%

GHG reduction

(beyond “business as usual”)



Why is this effort needed?

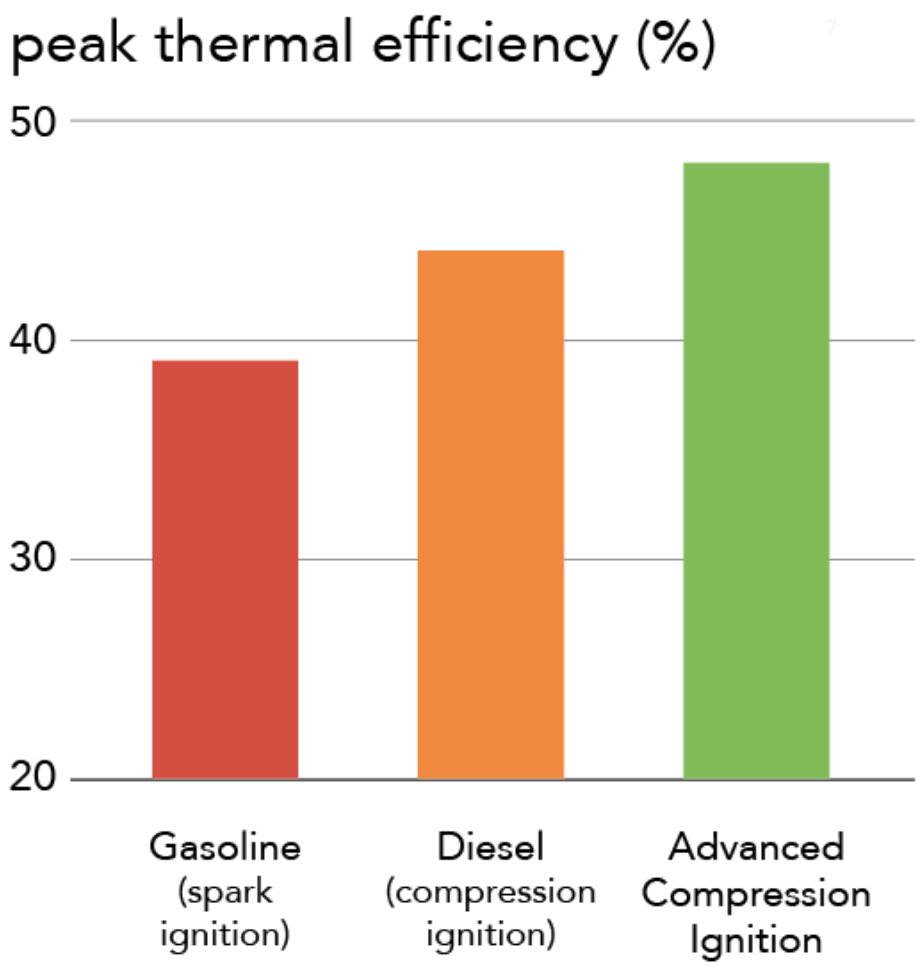
Engines

will dominate fleet

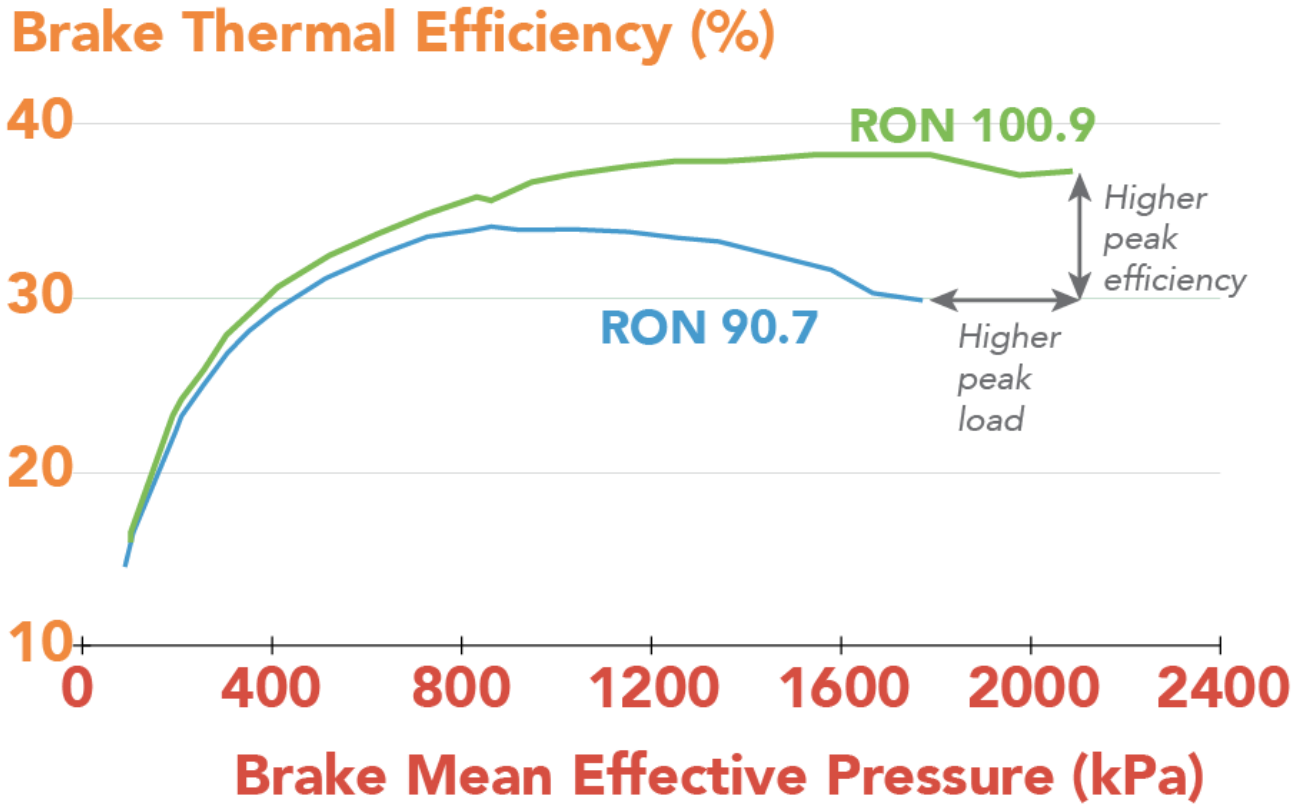
for decades

higher efficiency, low emission engines

are possible



Current fuels **constrain** engine design



Engine: Ford Ecoboost 1.6L 4-cylinder, turbocharged, direct-injection, 10.1 CR source: C.S. Sluder, ORNL

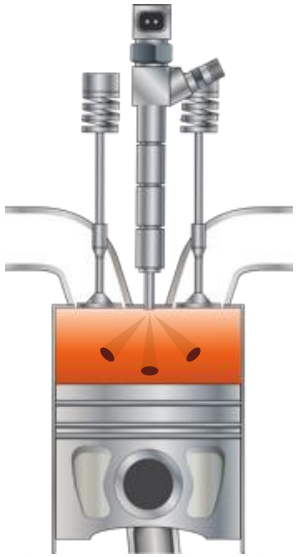
RON viscosity MON
volatility cloud point
bulk modulus of compressibility Wobbe index heating value
sensitivity heat of vaporization
soot precursor formation PMI flammability limits
smoke point
cetane number T50
heat of combustion flame stretch ignition limits
C/H ratio strain sensitivity
density specific heat ratio
naphthene level Markstein length
T10 surface tension flash point T90
exergy destruction olefin level
energy density sulfur level
laminar burning velocity
diffusivity drivability index flame speed
aromatics level oxygenate level

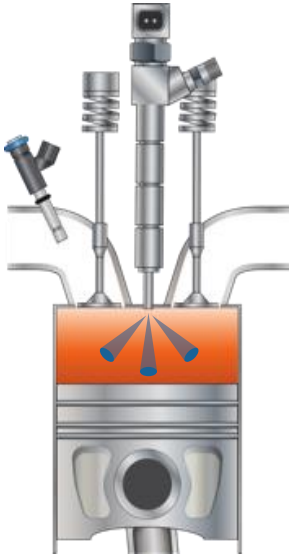
Fuel is more than just octane

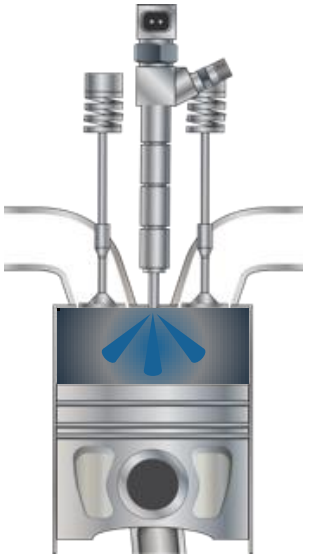
Parallel thrust efforts are underway

Thrust 1: Spark Ignition (SI)

Thrust 2: Advanced Compression Ignition (ACI) kinetically-controlled and compression-ignition combustion







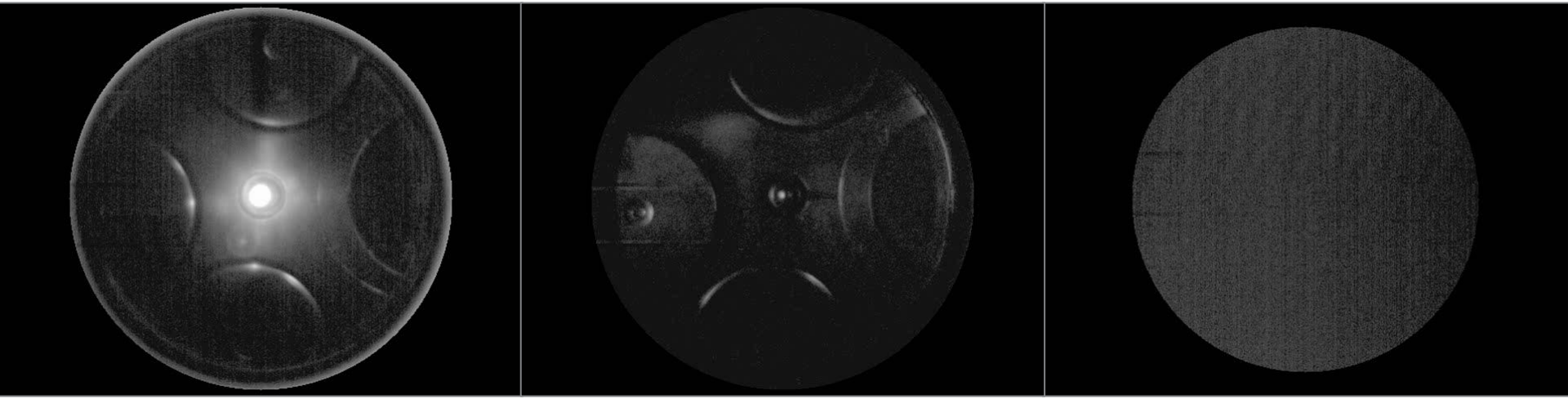
Low reactivity fuel

Range of fuel properties TBD

High reactivity fuel

Fundamentally different **combustion dynamics** require **different fuel properties**

Spark ignition (gasoline)	Kinetically controlled combustion	Compression ignition (diesel)



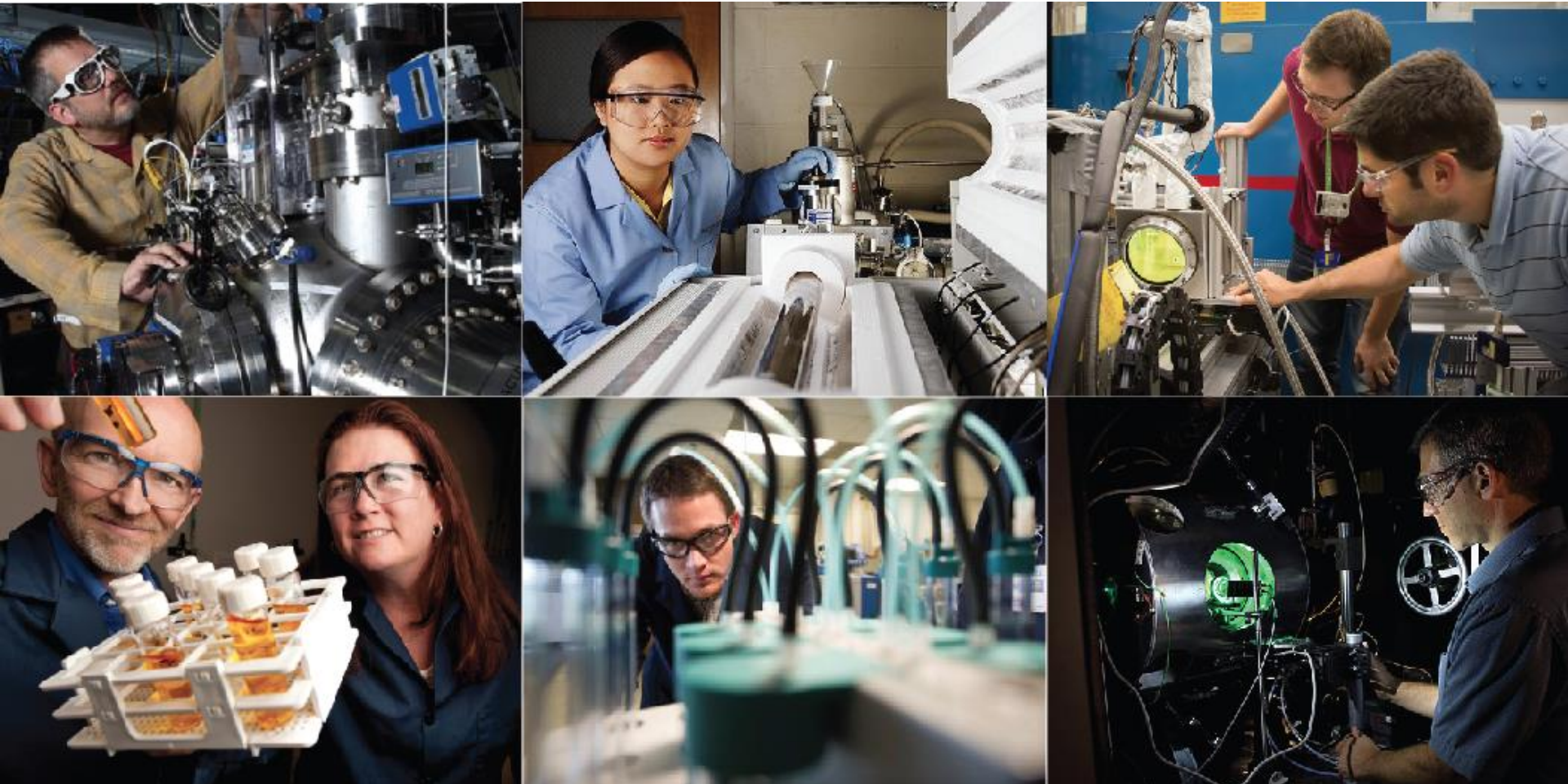
New fuels open up engine design options

boost level
ignition energy
valve lift
downsizing
tumble ratio
powertrain design
ignition timing
fuel stratification
compression ratio
air/fuel ratio
hybridization
swirl ratio
heat exchanger design
valve timing
injector design
cylinder deactivation
injection timing
direct injection
real time controls
EGR ratio
number of injections
injection pressure
charge temperature
on-board reforming
injection duration
on-board separation
valve overlap
turbulence
downspeeding

Applicable to **light, medium, and heavy-duty** engines

Co-Optima: Leveraging expertise and facilities from 10 national labs

Broad Diversity of Skills Critical for Success



Mobilize world-class research facilities

Integrated multi-lab teams with significant external stakeholder engagement

13 Light and heavy duty vehicle manufacturers

10 Oil companies/ refiners

8 Biofuel companies

4 Regulatory agencies

2 End consumer organizations

Identify and mitigate barriers to wide-scale deployment

Reality check time

Why another new fuel?

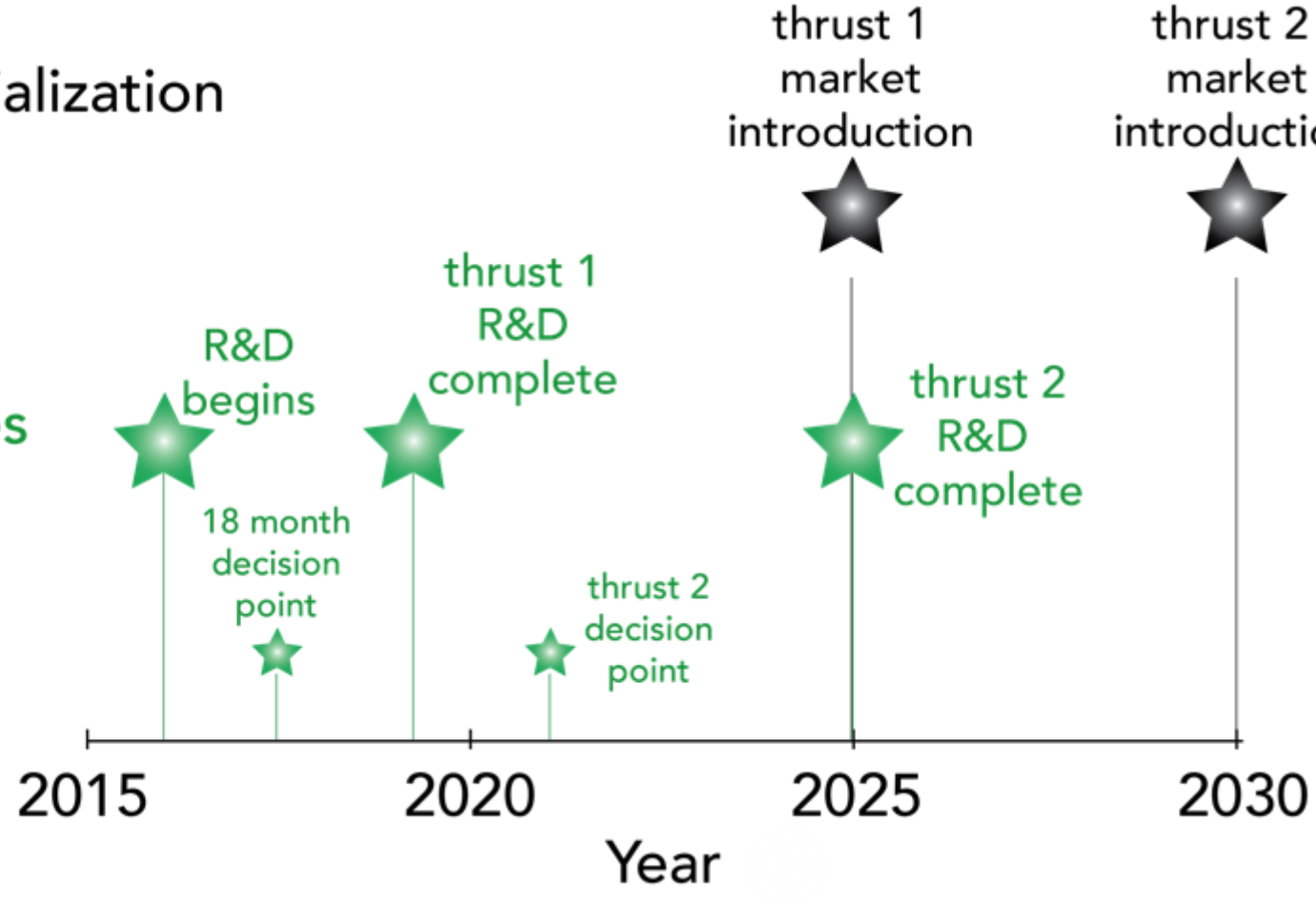
Why not just use ethanol blends?

Will the new fuels be compatible with current station hardware?

What about mis-fueling?

commercialization targets

R&D milestones



Summary

- Ambitious new Department of Energy initiative
- Accelerating introduction of affordable, scalable, and sustainable fuels and high-efficiency, low-emission engines
- Engagement with industry stakeholders critical to success

All photos in this presentation courtesy of Co-Optima national lab partners or iStock.

Thank You!